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U.H.F. radio links:
2·5 GHz transmitting aerials for mobile radio cameras

No. 1970/20

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

RESEARCH DEPARTMENT

U.H.F. RADIO LINKS: 2·5 GHz TRANSMITTING AERIALS FOR MOBILE RADIO CAMERAS

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(RA-61)

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U.H.F. RADIO LINKS: 2·5 GHz TRANSMITTING AERIALS FOR MOBILE RADIO CAMERAS

SUMMARY

With the increasing danger of mutual interference between u.h.f. television transmitters and outside broadcast links, it is becoming necessary to use frequencies outside the normal television bands for temporary links. Four channels have been allocated to O.B. links in the region of 2·5 GHz.

Two aerials for use on moving vehicles are described in this report, and they offer a choice of two vertical directivities whilst maintaining an omnidirectional horizontal radiation pattern.

1. INTRODUCTION

The aerials described in this report were developed for the purpose of transmitting television signals from mobile camera sources. They are at present considered as experimental and have been given to Communications Department for proving under actual operating conditions. The initial requirement was for two aerials for the 2·5 GHz band each to be vertically polarized and omnidirectional, having vertical beamwidths of approximately 60° and 30° respectively. The narrow-beam aerial is intended for transmissions from road vehicles. The aerial with the wider beam is proposed for use on a helicopter.

The four channels allocated for mobile links in the 2·5 GHz band are: 2·450 – 2·470 GHz, 2·552 – 2·568 GHz, 2·572 – 2·588 GHz and 2·592 – 2·608 GHz. Although it is intended that only the lowest channel will be used for helicopter links, it was desirable that the aerials should be capable of satisfactory operation in any channel to give maximum flexibility in operation.

2. THE 60 DEGREE AERIAL

A simple bicone, shown in Fig. 1, was chosen as the 60 degree aerial. The overall length of the radiating section is 10 cm. A cylindrical dipole of length 10 cm would give a similar beamwidth but the biconical element is easier to match over the bandwidth required.

The biconical element is fed by a solid 50 ohm coaxial feeder, which is connected between the apices of the two cones via a transforming section of line. A quarter-wave suppressor is fitted to limit the flow of unbalanced current on the outer of the feeder. Although this measure is only partially effective the

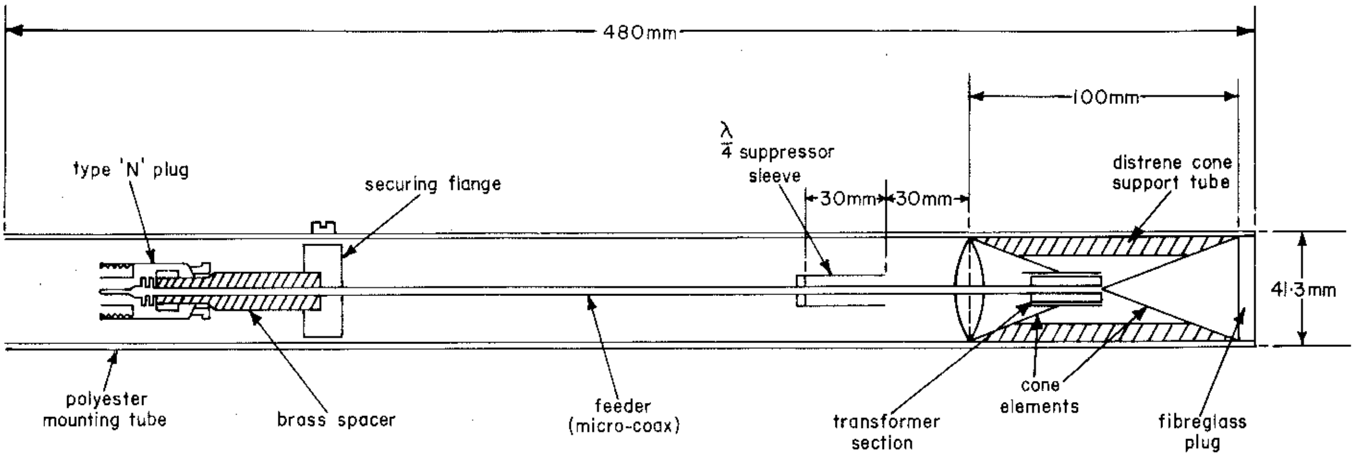

Fig. 1 - The bicone aerial

degree of asymmetry due to unbalanced current is not serious (see Fig. 2).

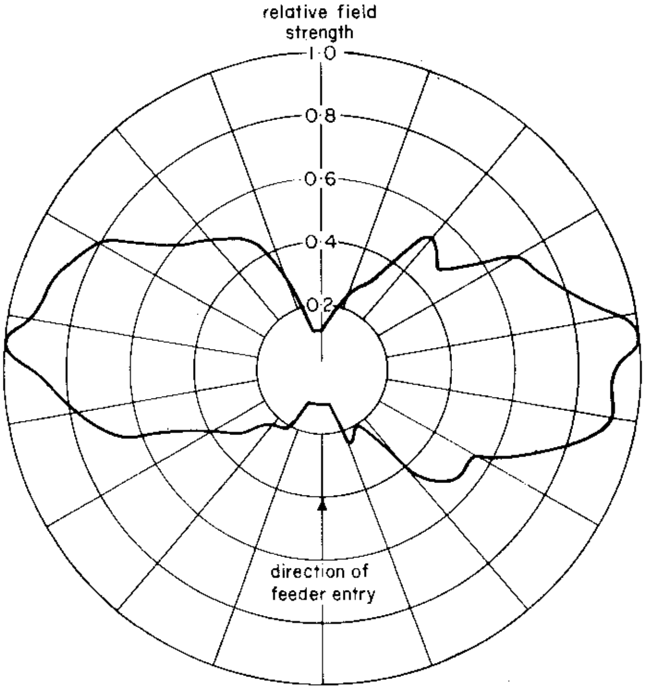

Fig. 2 - Vertical radiation pattern of prototype bicone at 2·5 GHz

A number of biconical and cylindrical elements of different dimensions were constructed, and the radiation patterns measured. The results, which were used to determine the dimensions of the prototype aerial, are shown in Fig. 3; good agreement with published measurements was obtained.[1]

It was found possible to match the bicone over the desired range of frequencies so that the reflection coefficient was less than 15%.

3. THE 30 DEGREE AERIAL

It was decided to design an aerial of the Franklin type for this application in order to achieve an increased radiating length with a single drive point. The basic centre-fed Franklin aerial is shown diagramatically in Fig. 4(*a*). The quarter-wave stubs in the basic arrangement were mechanically inconvenient for our application and we therefore adopted a modified form of this aerial using longitudinal sleeves. The arrangement is shown in Fig. 4(*b*). The sleeves are approximately $\lambda/3$ long but they are loaded with dielectric to make their internal electrical length $\lambda/2$. The radiating current distribution is approximately as shown by the full line; the current distribution on the central conductor inside the sleeves is as shown by the dotted line. The current flow at the end of the sleeves is indicated in Fig. 4(*c*). The E-plane radiation pattern of the practical aerial is shown in Fig.

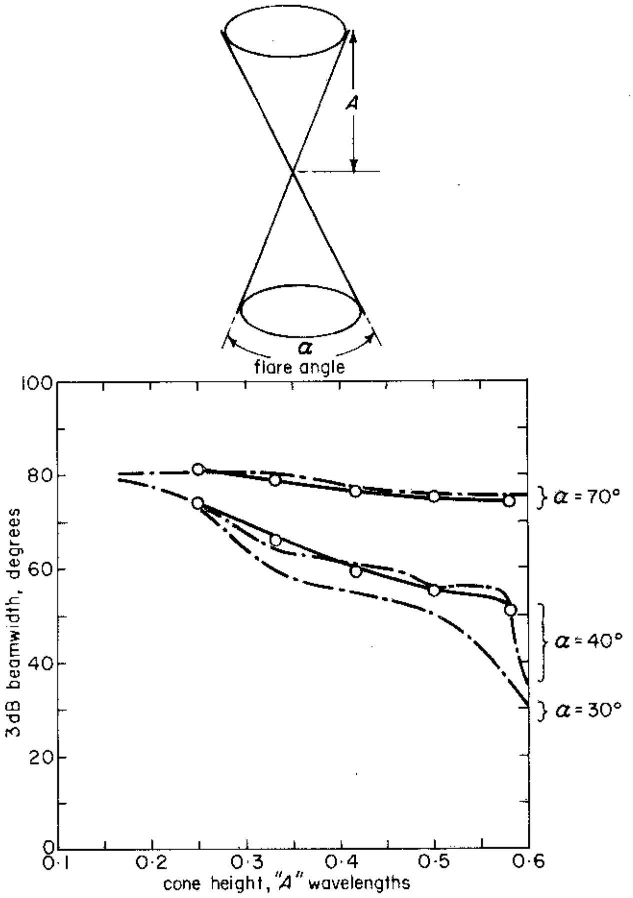

Fig. 3 - Bicone aerial: 3-dB beamwidth as a function of cone height for various flare angles

—o—o— Results obtained by the authors

—·— Curves plotted from results presented in reference 1

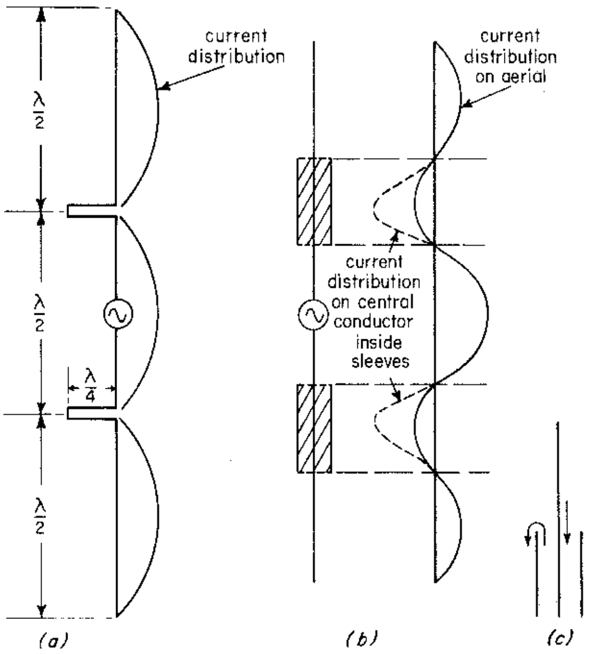
λ/2
λ/2
λ/4
λ/2
current distribution
current distribution on aerial
current distribution on central conductor inside sleeves
(a)
(b)
(c)

Fig. 4 - Basic arrangement of the Franklin aerial

(*a*) Basic, centre-fed Franklin aerial
(*b*) Practical form of sleeved aerial
(*c*) Current flow at end of sleeves

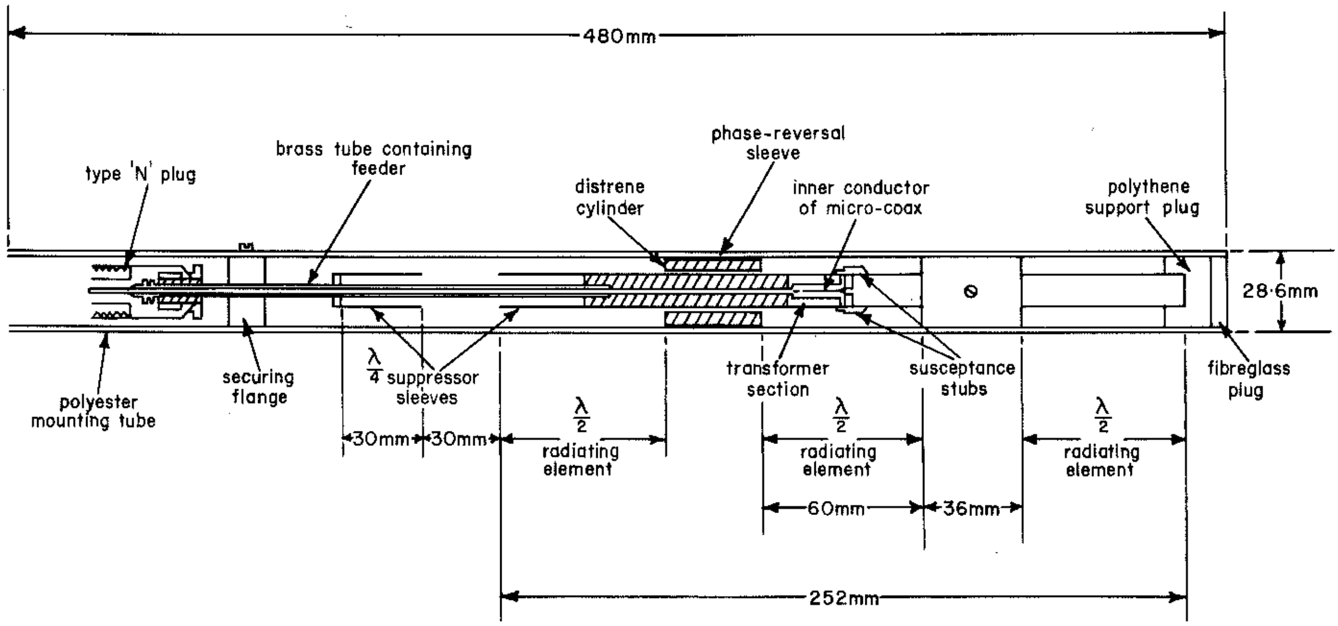

Fig. 5 - The practical Franklin aerial

6. Although the minor lobes are quite large it was judged that this pattern would be acceptable, particularly in view of the mechanical robustness offered by this type of assembly.

The aerial is shown in Fig. 5. Two λ/4 choke sleeves are used to suppress radiation from the outer of the feeder, and normal matching techniques embodying shunt stubs and a transformer section are used to match the aerial. Fig. 6 shows the vertical radiation pattern at 2·5 GHz, and Fig. 7 the reflection coefficient as a function of frequency.

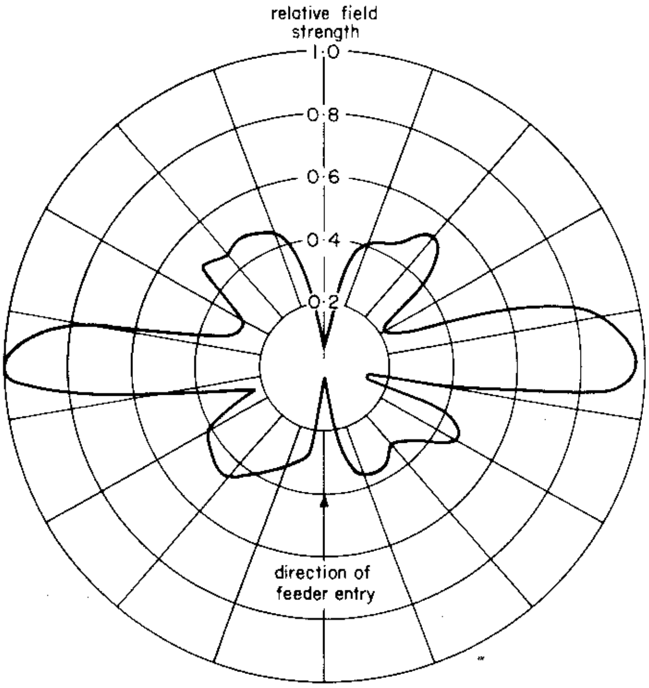

Fig. 6 - Vertical radiation pattern of prototype Franklin aerial at 2·5 GHz

The reflection coefficient (referred to 50 ohms) is not greater than 17% over the operational band of frequencies.

4. MOUNTING ARRANGEMENTS

Both aerials are enclosed in glass-reinforced plastic tubes for mechanical strength and protection against the weather (see Figs. 1 and 5). Figs. 8 and 9 show the finished aerials with and without the plastic tubes. It is intended that they should be fixed to vehicles or aircraft by inserting the cable end into a hollow metal boom, in which they are clamped. The feeder cable can be contained within the boom and may be led into

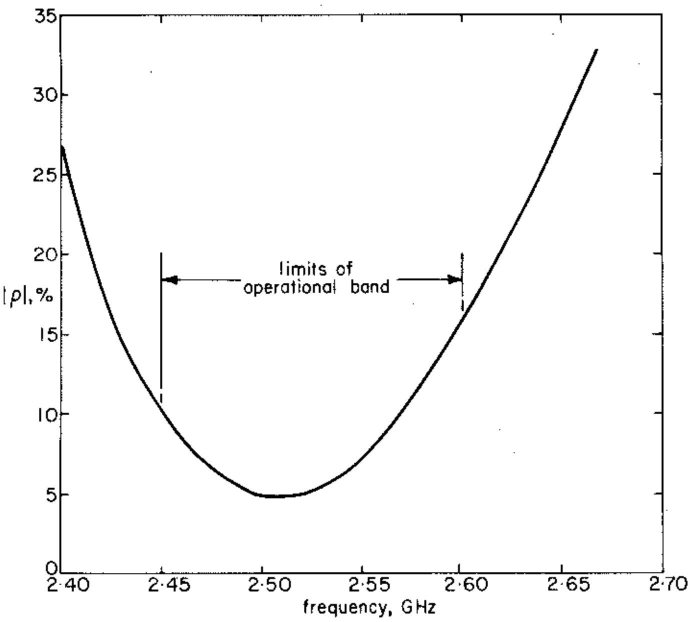

Fig. 7 - Reflection coefficient of prototype Franklin aerial as a function of frequency

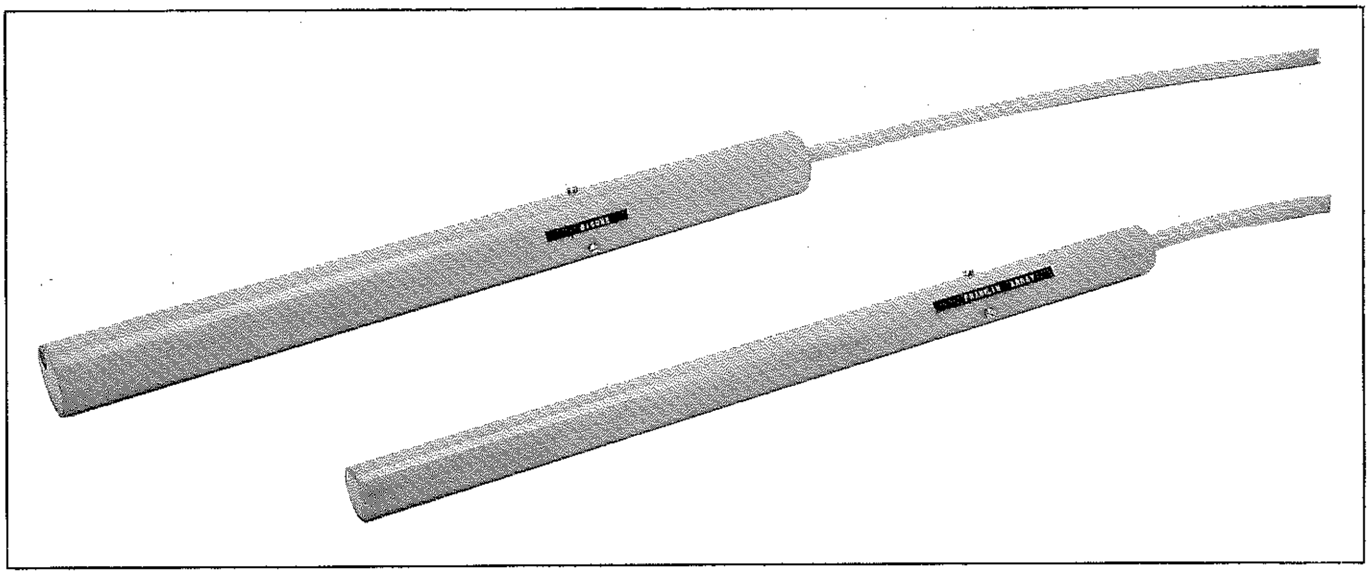

Fig. 8 - Bicone and Franklin aerials mounted in resin tubes

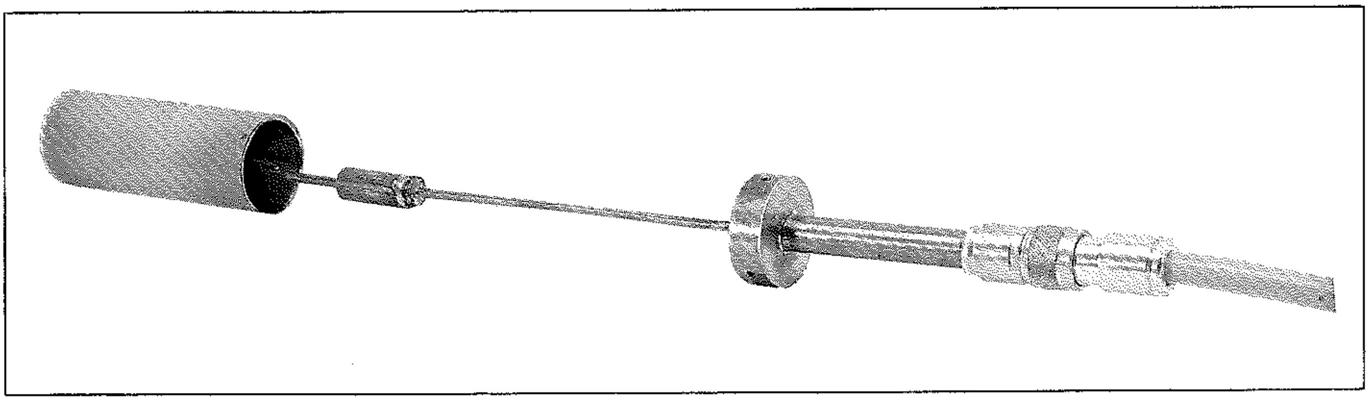

Fig. 9(a) Prototype Bicone

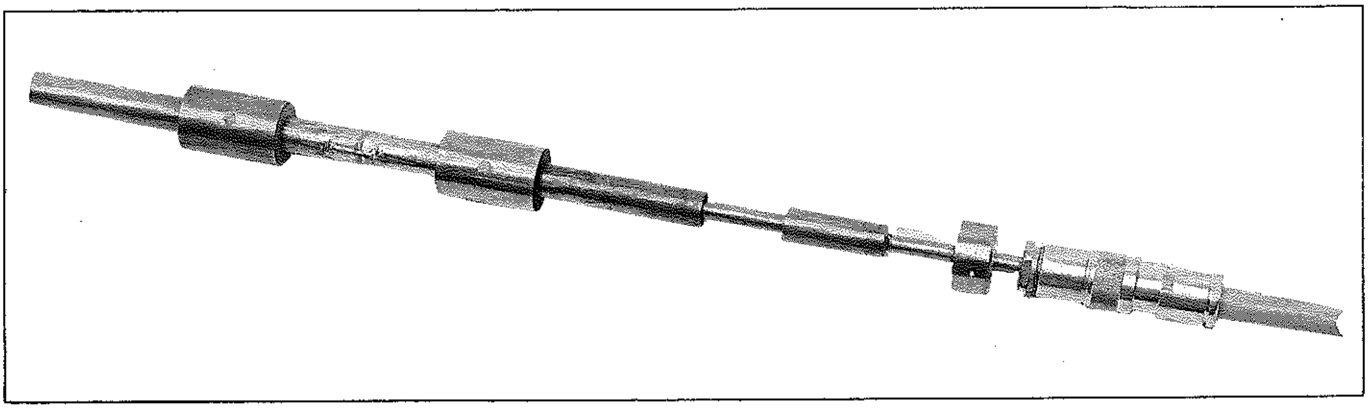

Fig. 9(b) Prototype Franklin aerial

the vehicle or aircraft without risk of fouling the superstructure. Other mounting arrangements could easily be devised to suit different circumstances.

Care had to be exercised in choosing suitable glass-reinforced plastic tubes, as serious losses can occur in many of the materials used commercially; the presence of a filler invariably introduces loss. In general, a polyester resin used with an 'E' quality glass reinforcement gives satisfactory results. The prototypes use tubes made from polyester resin reinforced with a woven glass matting; the surface is finished with a polyester varnish.

5. GAINS AND OPERATING RANGES

The gains of the bicone and Franklin aerials are approximately + 1 dB and + 4 dB respectively relative to a half-wave dipole. Assuming a transmitter power of 200 mW, using frequency modulation with a peak-peak deviation of 8 MHz, and a receiving aerial gain of + 20 dB, satisfactory performance can be envisaged for operating ranges of up to two miles.

6. OPERATIONAL TESTS

Operational tests were carried out at Hendon Aerodrome in conjunction with Television Outside Broadcast units. The two prototype aerials were used with O.B. 2·5 GHz link equipment. A roving-eye shooting brake was equipped with a colour camera and the link transmitter, using the prototype aerials for transmission. The received signals were observed in a stationary receiving vehicle on a colour picture monitor and video waveform monitor, while the shooting brake roved, simulating actual outside broadcast conditions. A parabolic dish aerial (gain + 20 dB) was used for reception, and was tracked normally. Good colour pictures were observed for the majority of the time although short bursts of severe multi-path reception caused break-up. The performance of the Franklin aerial appeared to be considerably better than that of the biconical aerial under these conditions, as the periods of picture break-up were shorter and therefore less disturbing, although the reasons for this improvement are not fully understood. The location for the tests had been chosen because of the known severity of the multi-path problem there. It was thought that the 2·5 GHz equipment under test gave greater continuity (e.g. a greater proportion of the time for which the pictures were usable) than other types of equipment in use.

7. FURTHER TECHNIQUES

It is suggested that the introduction of further equipment and more sophisticated techniques may be desirable to obtain the best results under roving-eye conditions of operation. These possibilities are:

(a) increased transmitter power (10 watts) using a travelling wave amplifier,

(b) a gyro stabiliser to maintain the vertical attitude of aerials on helicopters and

(c) a high gain aerial at the receiving terminal employing automatic tracking.

It is hoped that further tests with the equipment will indicate which techniques should be pursued in the future.

8. REFERENCE

1. BROWN, G.H. *and* WOODWARD Jr., O.M. Experimentally determined radiation characteristics of conical and triangular antennas. *R.C.A. Review* **XIII**, 4, pp. 425-452 (December 1952).

JMP/PF

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